Comparison of test and analytical results of vibration level in a truss structure

W Ben Tsoi
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

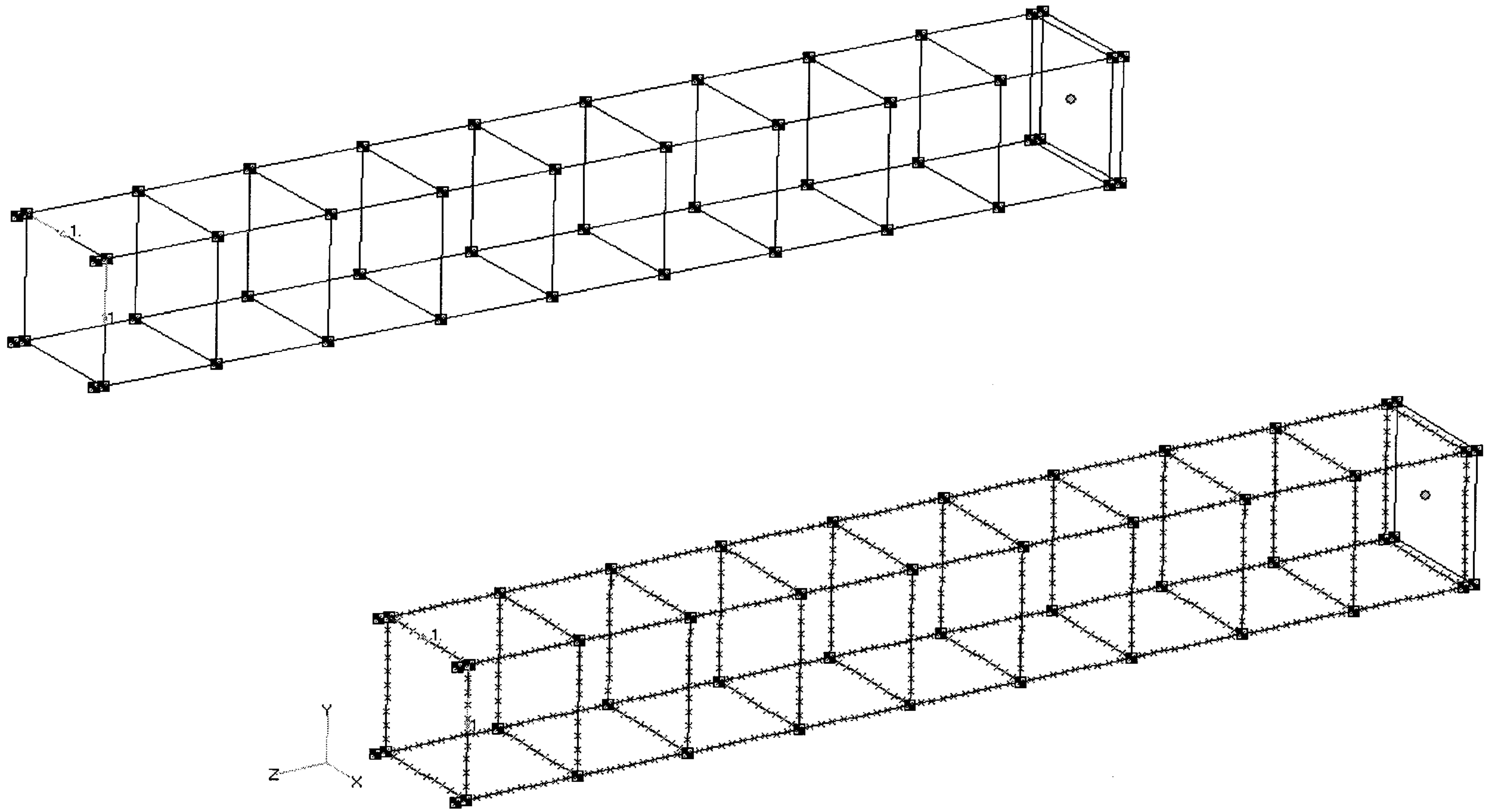
Introduction

- Interferometry Program Experiment post flight ground test
- IPEX-2 test article consists of a 9-bay truss boom structure with 6 support struts.
- Deployable structure made up of graphite longerons and battens, with steel pretension cables and fittings.
- Random excitation applied at tip and responses are recorded at joints

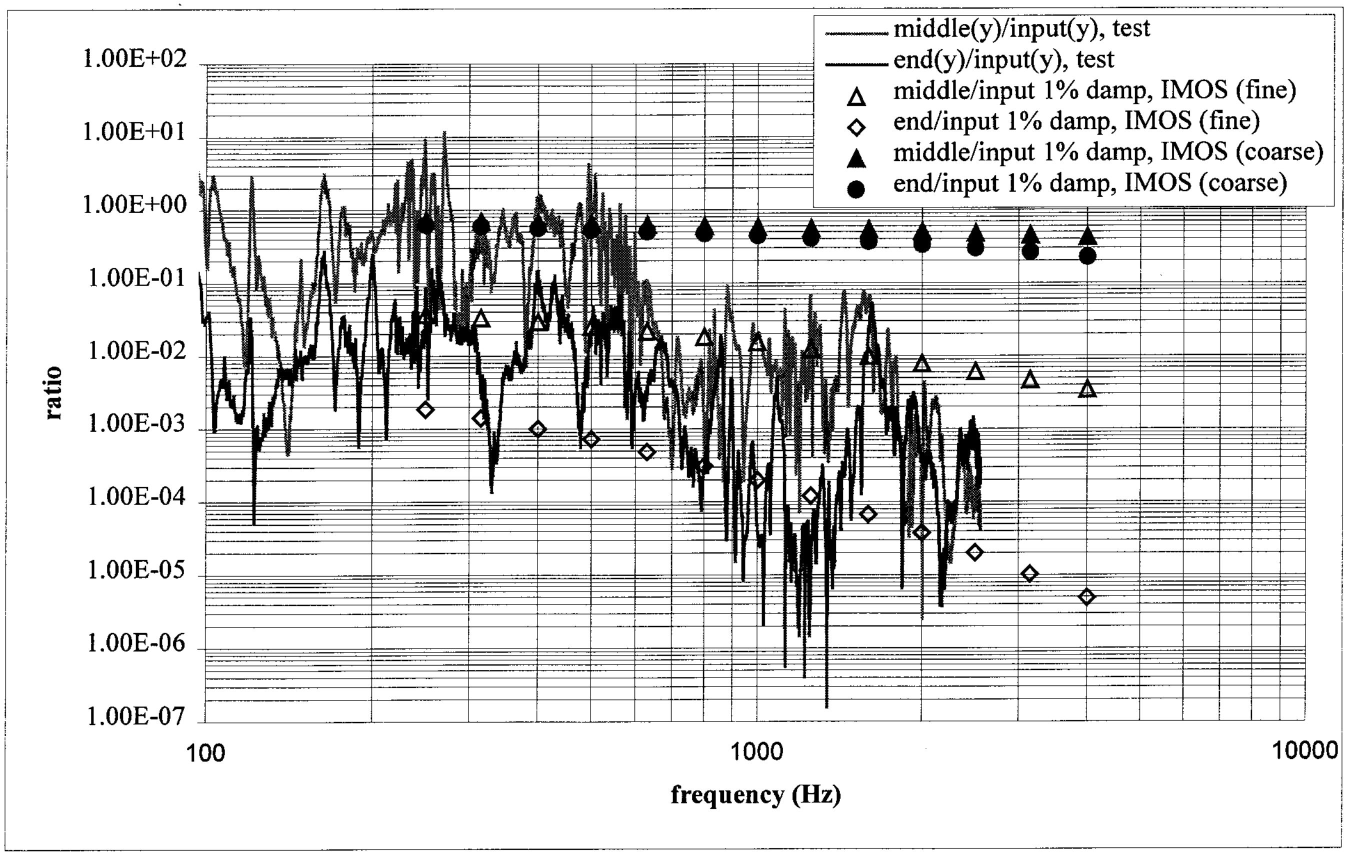
SEA Approach

- In-house SEA software
- Only 2 bending and 1 torsion waves in beams (no translation at ends of beams)
- Cables and masses are not modeled
- Time average modal energies of the two bending & torsion mode of each beam are equal
- Non-directional vibration level of beam is calculated
- result varies with mesh density

SEA Model



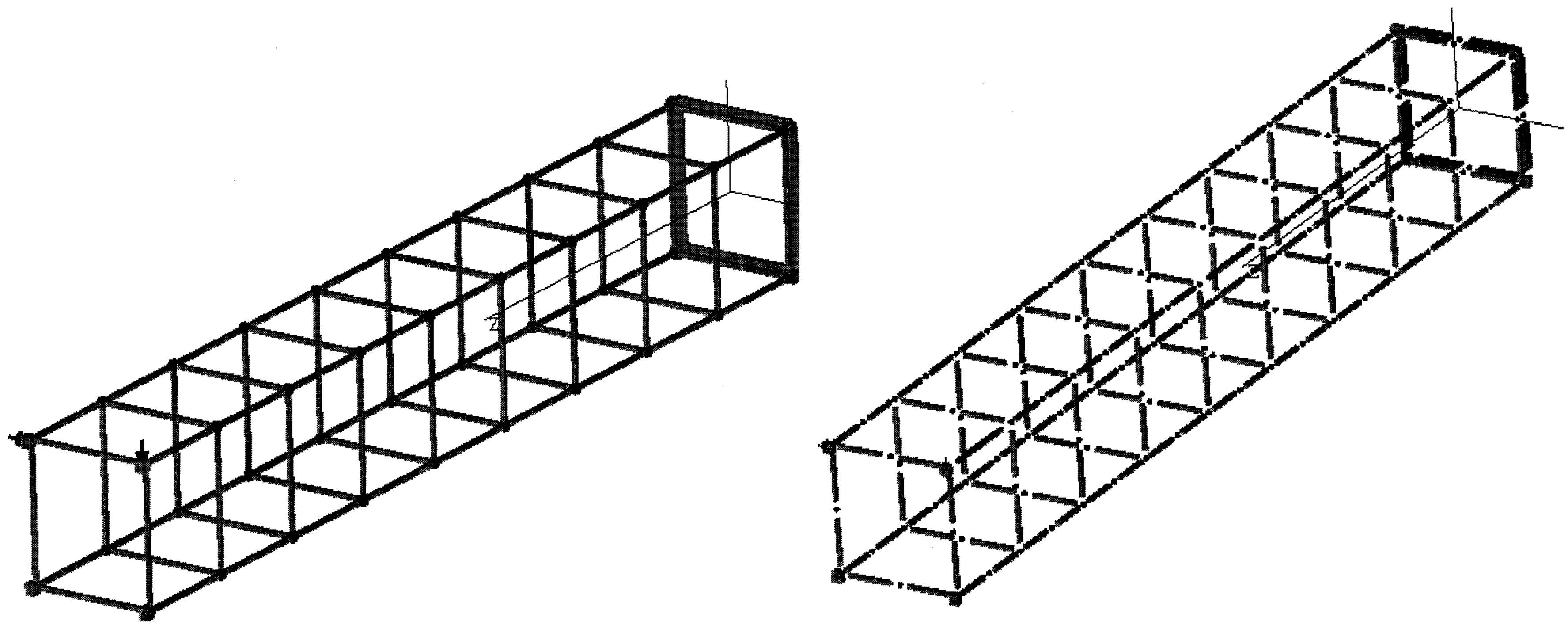
Result - SEA vs Test



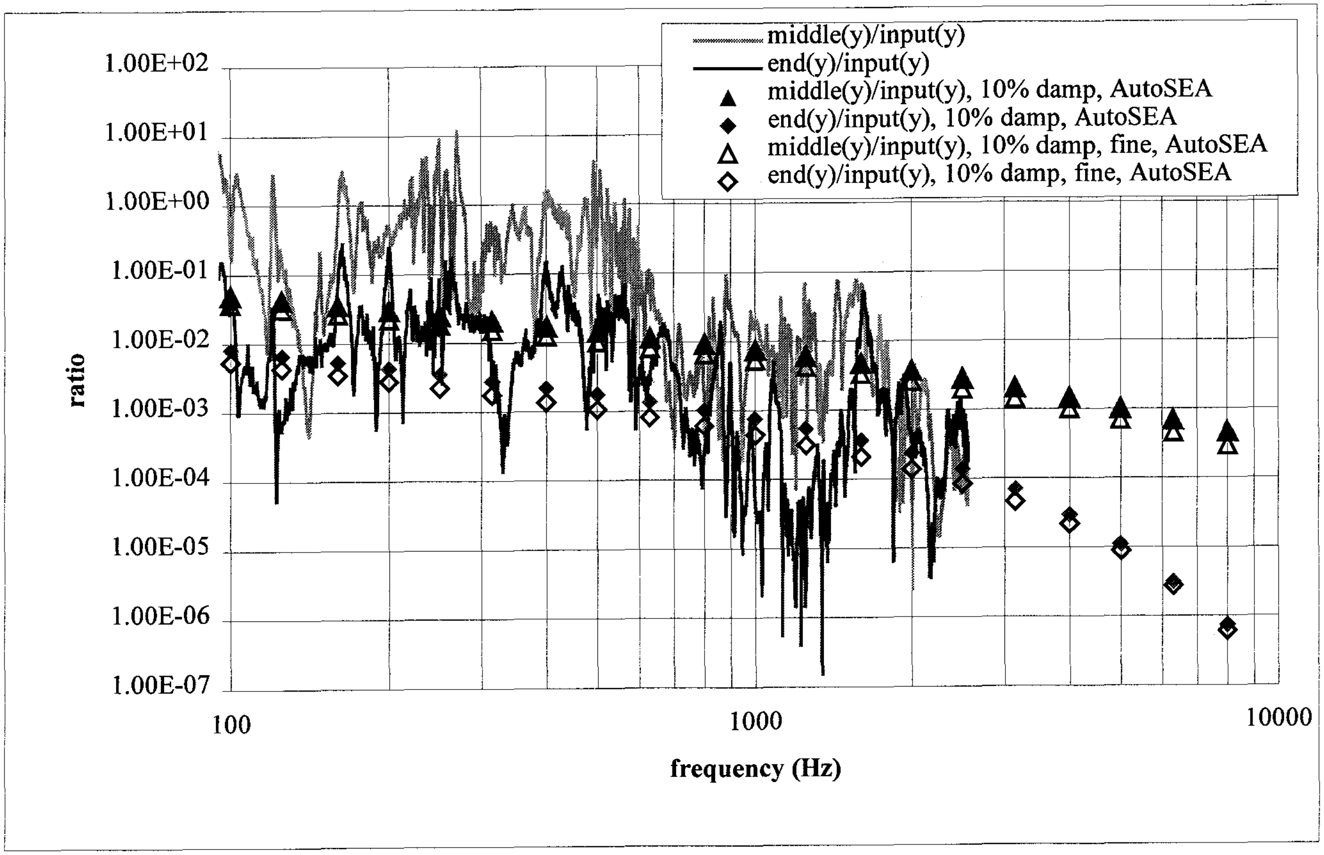
AutoSEA Approach

- 2 bending, 1 torsion and 1 longitudinal waves in beams
- Cables and pully masses are not modeled
- Vibration levels in all 4 directions are calculated
- result varies with mesh density

AutoSEA Model



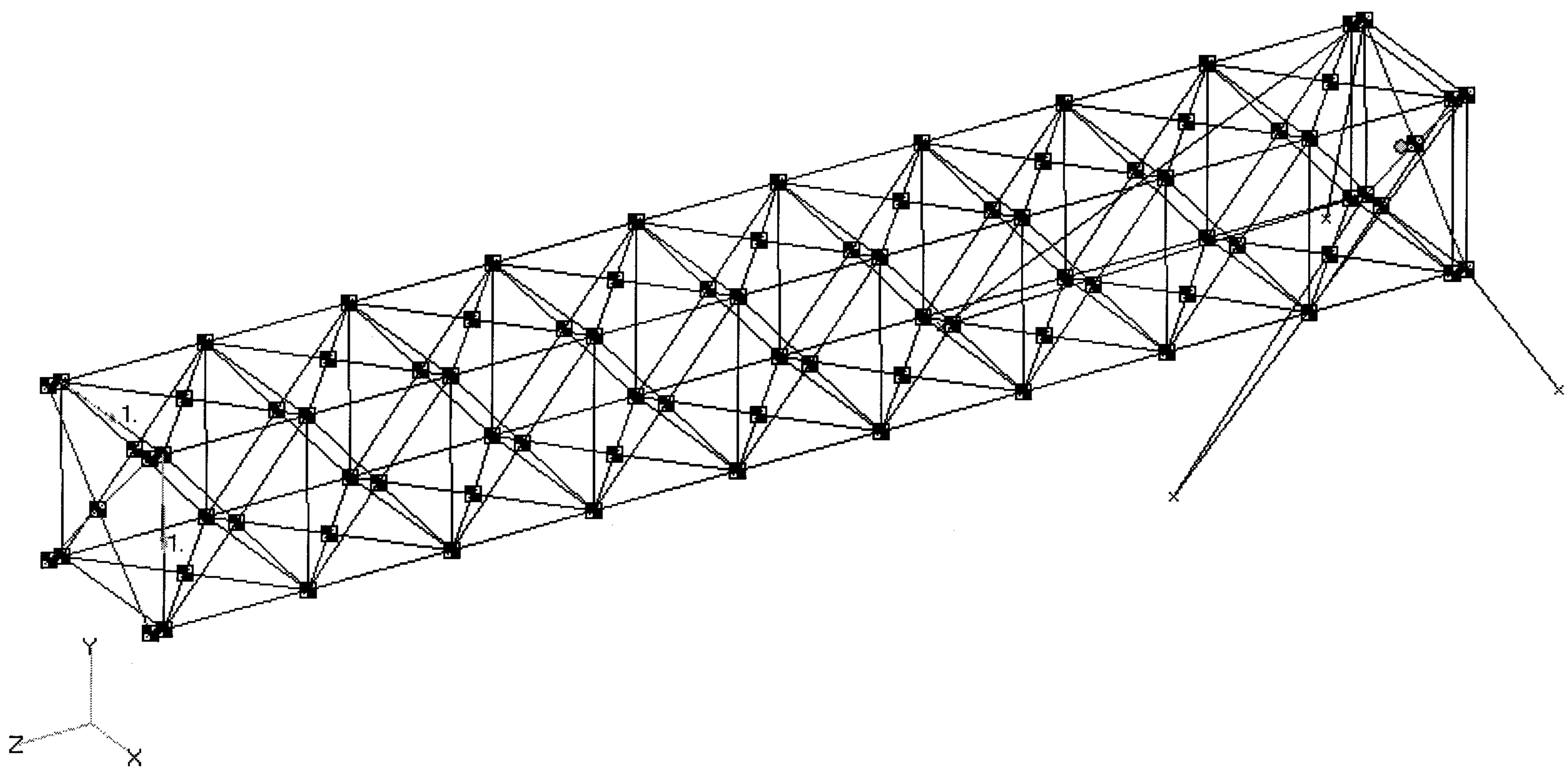
Result - AutoSEA vs Test



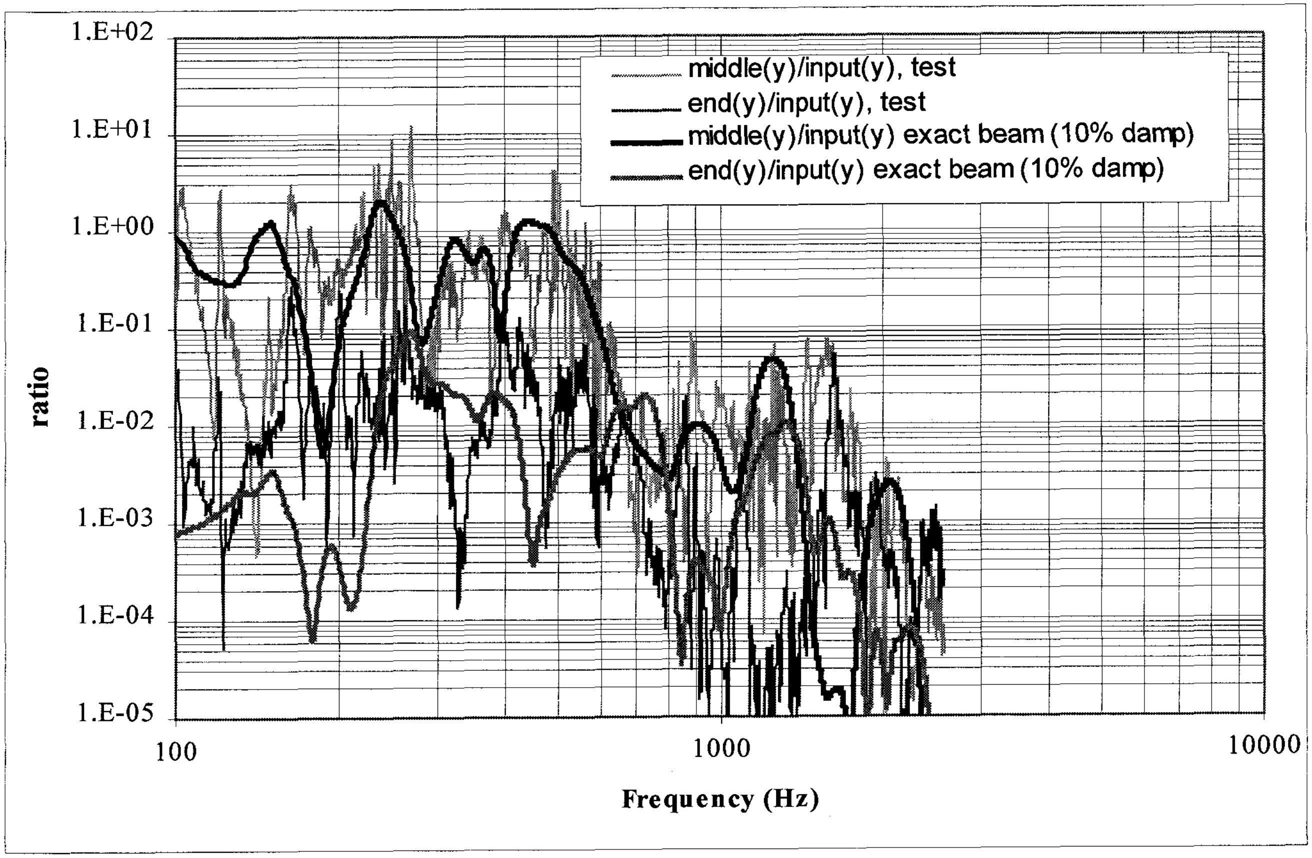
Analytical Beam Approach

- Use analytical solution to the differential eqns for longitudinal, bending and torsion waves in beams
- Find the response to all loading conditions at the end of a beam, masses attached at the end of beams are included
- Organize the analytical expressions for the beam response into the same form as a FEM elemental stiffness matrix
- Setup the analytical solution by standard FEM assemble process
- One element per beam, results at both ends only

Analytical Beam Model



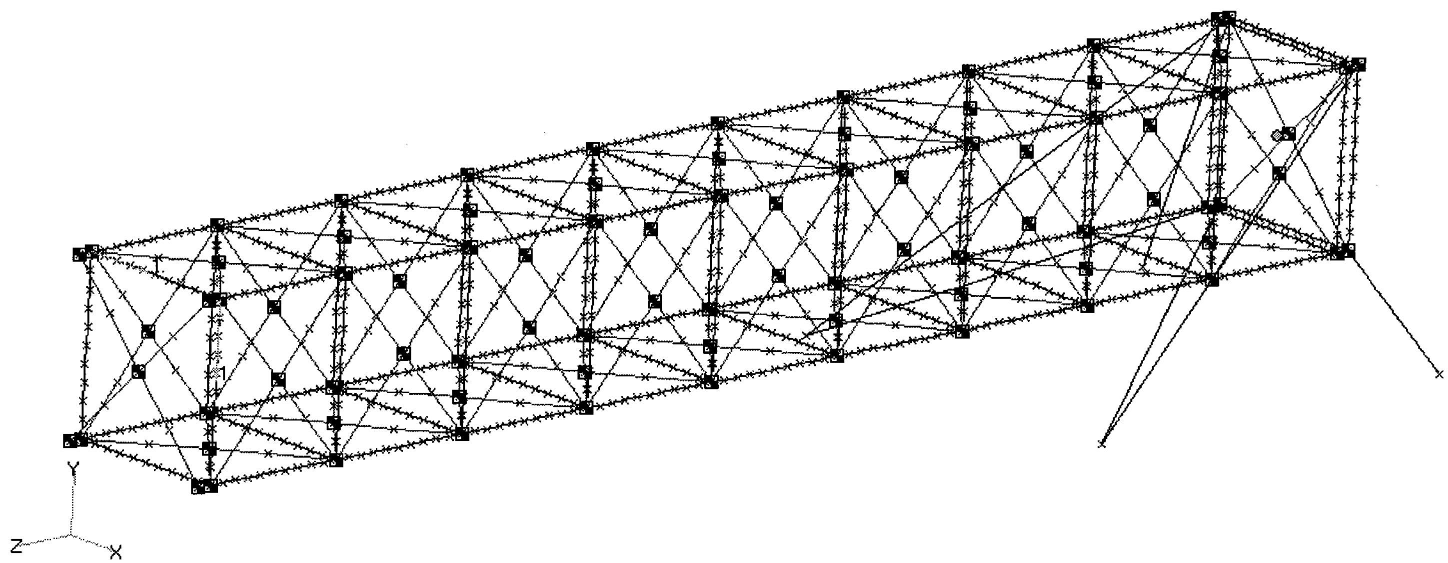
Result - Analytical Beam vs Test



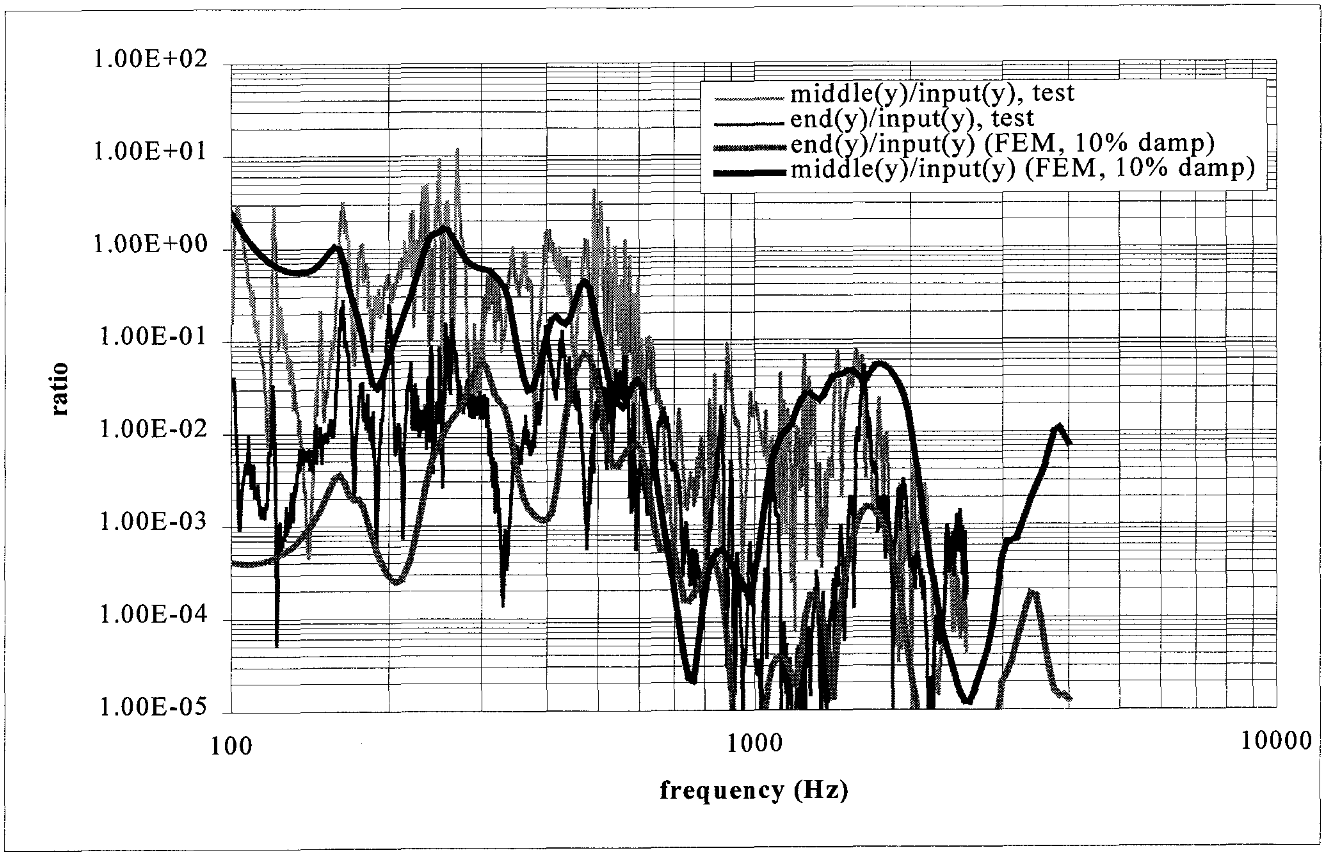
FEM Approach

- Truss, support struts, and cable are modeled by bar element.
- Corner fittings, actuators, sensors, and latch/pully mechanisms are modeled by point mass.
- Preload in cable is ignored.
- Modal frequency response is obtained.

Finite Element Model



Result - FEM vs Test



Conclusion

- **SEA provides space and time averaged responses while FEM and Analytical Beam approaches model modal characteristic of structure**
- **Finer SEA models result in low responses due to "cascading effect" of multipling DLFs.**
- **Need "cable" elements in FEM, Analytical Beam and SEA models.**